Dinara Massif – a new hotspot for the butterfly (Papilionoidea) diversity of the Dinaric Arc

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Abstract. The Dinara Massif range is the highest mountain range in Croatia, located in the southeastern part of the country. During the last three years we conducted a butterfly survey on three mountains belonging to the Dinara Massif: Dinara, Kamešnica and Troglav. We recorded 94 butterfly species; for the first time exact localities were given for 46 of them, while two were entirely new records for the area. A comparison with five other mountains belonging to the Dinaric Arc was performed using the Sørensen similarity index, which revealed that Blidinje (Čvrsnica & Vran complex) in Bosnia and Herzegovina, and Mt. Velebit in Croatia have the highest similarity with the Dinara Massif. Several rare species were recorded during this survey, of which *Polyommatus ripartii* (Freyer, 1830) represents the second record for Croatia. The known ranges for *Pieris balcana* (Lorković, 1970), *Polyommatus damon* (Dennis & Schiffermüller, 1775), *Polyommatus eros* (Ochsenheimer, 1808) and *Polyommatus ripartii* in Croatia were much expanded.

Introduction

Butterflies are one of the best studied groups of insects in most of Europe, especially in terms of their biology, distribution (Kudrna et al. 2011), ecology (Settele et al. 2009) and conservation status (van Swaay et al. 2010). One of the commonly used tools to unite all the data in one place are butterfly atlases, which are more the exception than the rule in the Balkan region. Only a single butterfly atlas exists for the region, and it covers the butterflies of Slovenia (Verovnik et al. 2012). In Bosnia and Herzegovina a book covering butterfly diversity exists (Lelo 2007a) but covers only their general distribution, without precise localities. The same goes for the field guide to the butterflies of Serbia (Popović & Đurić 2011). Aside from the 20-year old atlas that covers the entire territory of former Yugoslavia (Jakšić 1988), Croatia, Montenegro and Macedonia do not have any recent atlases. The above mentioned old atlas (Jakšić 1988) gives no data for many areas, and many species were recorded only sporadically. In Croatia, three main biogeographical regions exist: the Mediterranean, the mountain or Dinaric region and the continental region (State Institute for Nature Protection 2011).

One of the most interesting areas for the global species diversity is the Dinaric Arc. This is a south European mountain chain, spanning through Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Serbia and Albania. It extends for 645 kilometers along the coast of the Adriatic Sea (northwest-southeast), from the Julian Alps in the northwest, down to the Šar-Korab massif in the south. The highest mountain of the Dinaric Alps, Maja Jezercë, is 2694 m high. It is located in Mount Prokletije, on the border between Montenegro and northern Albania. The mountain range itself was

named after Mt. Dinara, located at the border of Croatia and Bosnia and Herzegovina. The Dinarides contain a mosaic of Alpine, Continental and Mediterranean species and habitats (Tvrtković & Veen 2006). The geology of the Dinaric Arc mostly consists of carbonate rocks (limestone and dolomite) with islands of clastic rocks and flysch rocks (Gottstein-Matočec 2002). The Dinaric Arc is influenced both by Mediterranean and the Continental climates (Tvrtković & Veen 2006). In fact, the border of those two zones lies along the mountain chain.

Butterflies were sufficiently surveyed only on several mountains belonging to the Dinarides chain, including Učka, Velebit and Biokovo in Croatia, Blidinje in Bosnia and Herzegovina and Durmitor in Montenegro. The highest mountain in Croatia, Dinara, is still a mystery in terms of biodiversity. Recently, an overview paper was published (Tvrtković et al. 2012) in which all the known records for the area were compiled, including literature records. Unfortunately, it lacks precise observation on localities and clear division of literature and recent records. Before that, no systematic surveys were ever carried out in this area, and literature data for the whole Dinara Massif are few (Koren 2010b; Koren et al. 2010; Lorković 2009; Mihoci et al. 2006; Mladinov 1973; Mladinov & Lorković 1985; Sijarić 1977; Stauder 1920/21; Tvrtković et al. 2011). A need for more systematic surveys is emphasised by the fact that for two butterflies, *Colias caucasica* Staudinger, 1871 and *Erebia triaria* (de Prunner, 1798), the Dinara Massif is the only known locality in Croatia (Lorković 2009; Tvrtković et al. 2011).

The aim of this paper is to present newly collected data on the biodiversity of three mountains in the Dinara mountain chain (Troglav, Dinara and Kamešnica), to give an overview of all known butterflies of the region, to present remarks on some interesting species and to compare them to other well-surveyed mountain regions of the Dinarides.

Materials and methods

Study area. The Dinara Massif is characterised by a diverse landscape covered with miscellaneous habitats. All of the surveyed mountains share the same type of vegetation structure. Dinara, Troglav and Kamešnica are mostly covered with different types of grasslands (Fig. 1). There are sub-Mediterranean and epi-Mediterranean dry grasslands that develop on shallow calcareous soil, and occasional meadows on richer brown soil. At higher altitudes are alpine and subalpine grasslands that grow above the tree line. In the past these grasslands were used as pastures or hay meadows, but today after abandonment of traditional outdoor livestock farming they are under severe succession. Dry grasslands are overgrown with scrubs and garrigue and eventually turn into sub-Mediterranean, thermophilous forests and scrubs of *Quercus pubescens* Willd. (Fagaceae), while alpine and subalpine grasslands are exposed to succession with different scrubs or Mountain pine (*Pinus mugo* Turra; Pinaceae). Beside these grasslands, the second most represented habitat types are forests. These are mostly thermophilous forests and scrubs of pubescent oak (*Q. pubescens*) in different degradation stages, and at higher altitudes beech (*Fagus sylvatica* L.; Fagaceae) and pine (*Pinus sylvestris* L. and *Pinus nigra* Arnold; Pinaceae) forests are present (Dumbović et al. 2009).

Fig. 1. a) Troglav, **b**) Kamešnica, Međugorje, **c**) Dinara, Duler, **d**) Dinara, Brezovac.

Data collection. All data presented in this paper are the result of a three-year study by the authors. Dinara was visited in May 2010 and May 2012; Kamešnica in May 2010, and July and August 2012; Troglav in July 2011. These visits covered the whole season of butterfly activity. The visited area of Troglav is especially dangerous, because of many land mines left after the last war twenty years ago. Aside from that, the road leading to the upper part of the mountain is inaccessible by an ordinary vehicle. All these factors make researching this area very dangerous. The survey was carried out on 26 different localities (Tab. 1).

Butterflies were caught with entomological nets, identified, and released on the spot. The sampling was mostly carried out using a transect method, when possible. Time spent on each locality varied, but was at least half an hour per locality. In several cases identification was not possible in the field, so the specimens were collected and the genitalia prepared by standard procedures. Exact coordinates and altitudes were recorded using a Garmin GPS device, altitudes were double-checked in Internet mapping tools (GoogleEarth, GoogleMaps). The taxonomy follows van Swaay et al. (2010).

Data processing. Recorded butterfly diversity was compared to five other, moderately well-surveyed mountains of the Dinaric region. Three of them are located in Croatia – Učka (Rebel 1910), Velebit (Mihoci et al. 2007) and Biokovo (Mihoci et al. 2011), one

Tab. 1. List of surveyed localities on Dinara Massif, with UTM fields, coordinates, altitudinal range and habitat types. ▲Coordinates are set to GCS_Bessel_1841 geographic coordinate system.
* Habitat types: **AG**: alpine and subalpine grasslands, **CS**: cultivated surfaces, **DG**: dry grassland, **FE**: forest edge, **HM**: hay meadow, **P**: pasture, **WB**: water bodies.

	Locality	UTM	Coordinates▲		Altitude range (m a.s.l.)	Habitat*
	Mt. Dinara					
1.	Guge	WJ98	44.06151 N	16.24180 E	245–375	DG, FE, CS, WB
2.	Ćurkove staje	XJ08	44.07236 N	16.27467 E	525–772	DG, HM, P, FE
3.	Matića Guvno	XJ08	44.10240 N	16.30711 E	937–1012	DG, HM, P, FE
4.	Brezovac valley	XJ08	44.10474 N	16.34611 E	1006	AG, HM, P, FE
5.	Duler valley	XJ08	44.08503 N	16.36169 E	1190–1129	AG, HM, P, FE
6.	Smiljina poljana	XJ08	44.07383 N	16.36294 E	1221–1230	AG, FE
7.	Mountain shelter Martinove košare	XJ17	44.04841 N	16.41101 E	1432	AG, FE
8.	Kobilovača	XJ17	44.02824 N	16.41162 E	809–1175	FE
9.	Glavaš	XJ17	44.00999 N	16.42508 E	566	AG, P
	Mt. Troglav					
10.	Jankovo Brdo	XJ27	43.96625 N	16.54635 E	1573–1593	AG
11.	Troglav peak	XJ26	43.94791 N	16.59702 E	1611–1910	AG
12.	Katića Torine	XJ36	43.91892 N	16.61023 E	1393–1530	AG, FE
13.	Popovača area	XJ36	43.87617 N	16.65166 E	1210	AG, FE
14.	Maglaj peak	XJ36	43.87659 N	16.67122 E	1380–1400	AG, P
15.	Mountain house Jakov Bitelić	XJ35	43.85848 N	16.64602 E	1000	P
	Mt. Kamešnica					
16.	Ovrlja spring, at the base	XJ43	43.68173 N	16.75118 E	260	DG, FE, WB, CS
17.	Rože settlement	XJ43	43.66345 N	16.83977 E	772–945	DG, HM, P, FE
18.	Korita village	XJ44	43.70125 N	16.81787 E	688–786	DG, FE, WB
19.	Ruda staje	XJ44	43.69164 N	16.85270 E	1083	DG, FE, P
20.	Međugorje	XJ54	43.69300 N	16.88528 E	1350–1384	AG, FE, HM, P
21.	Mountain shelter Sv. Mihovil	XJ53	43.68595 N	16.88976 E	1208–1348	AG, FE
22.	Arkačica settlement, Mt. Kamešnica	XJ53	43.66302 N	16.91556 E	1012–1030	DG, HM, P, FE
23.	Village Voštane	XJ53	43.64452 N	16.90586 E	865–944	DG, HM, P, CS, FE
24.	Crno polje, Voštane	XJ53	43.61592 N	16.90107 E	765	DG, P, FE
25.	Settlement Vrandolac, Donja Tijarica	XJ53	43.60055 N	16.89362 E	640	DG, FE, P
26.	Settlement Tarabnik, Donja Tijarica	XJ52	43.58835 N	16.90025 E	625	DG, HM, FE

in Bosnia and Herzegovina – Blidinje (Kučinić et al. 2005), and one in Montenegro – Durmitor (Sijarić et al. 1984) (Fig. 2). For the comparison of faunal similarity, we used the widely accepted Sørensen similarity index (Sørensen 1948). This similarity index measures species composition between two different sites, and takes into account the number of species shared by the two sites. The higher the value of the index, the higher the similarity between sites.

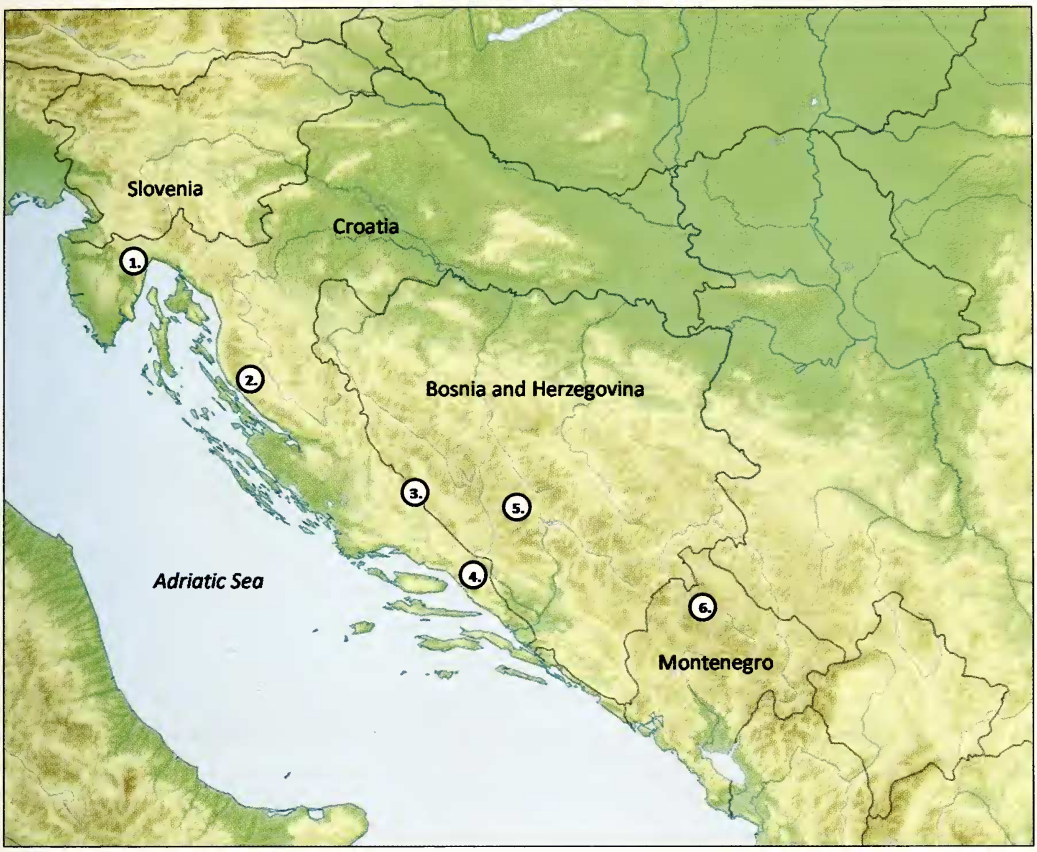

Fig. 2. The best surveyed mountains in the Dinaric region: **1**. Mt. Učka, **2**. Mt. Velebit, **3**. Mt. Dinara, **4**. Mt. Biokovo, **5**. Blidinje, **6**. Durmitor.

Results and Discussion

Faunistic data

A comparison of our data with the literature is somewhat challenging, due to the lack of detail in a recent overview done by Tvrtković et al. (2012). In that paper the authors published data from their own survey stretching from the village Guge (250 m a.s.l.) near Knin to the Sinjal peak (1831 m a.s.l.), but without any means of distinguishing between parts of the transects. Additionally, species from a historically surveyed locality near Knin (Hafner 1994) were included. These data are inconclusive due to the fact that the city itself is not part of the discussed area as it is located in the karstic valley of Kninsko Polje, with different geographical, geological, climatological and biodiversity characteristics. The main problem is that Hafner (1994) did not research the mountain itself, but only locations around the city. The best indication of this is the fact that not a single mountain species (e.g., genus *Erebia*) was listed in that paper, even though the survey lasted for several years, and an impressive number of species was recorded. Therefore the main problem is how to distinguish the historical data coming from one small area around the city of Knin, and recent data that include both the city area and

the Mt. Dinara itself. In either case, without exact localities available, the number of 130 recorded species given by Tvrtković et al. (2012) for the whole Dinara Massif should be taken with caution.

During this survey we recorded 94 different butterfly species (Tab. 2). For 46 of those species we provide for the first time their exact localities on the three surveyed mountains. However, 43 of these species were previously mentioned by Tvrtković et al. (2012), and only three are mentioned for the first time: *Pyrgus alveus* (Hübner, 1803), *Polyommatus ripartii* (Freyer, 1830) and *Hipparchia syriaca* (Staudinger, 1871). Looking at each mountain separately, we recorded 40 species on Dinara, 55 species on Troglav, and 58 on Kamešnica. Of those species, two are for the first time recorded on Mt. Dinara, 41 on Mt. Troglav and 30 on Mt. Kamešnica (Tab. 2).

With our newly collected data, and the literature data, the number of butterfly species in the Dinara Massif reaches 128 (Tab. 2). Species listed by Tvrtković et al. (2012), which we have not recorded and were listed only for the Knin area, are excluded from the list.

The results of the first study of the Dinara Massif show that the butterfly diversity of this mountain is high and rank it among the richest regions in Croatia (Mihoci et al. 2011). In Croatia, only Mt. Velebit has more recorded species (Mihoci et al. 2007). The butterfly diversity in the other regions of the country, like northern Croatia or Istria, is significantly lower than in the mountain complexes. Mt. Velebit and the Dinara Massif, for example, are influenced by different climate classes and contain numerous habitats, which result in the variety of butterfly species that occur there.

The Sørensen similarity index showed that the most similar areas to the Dinara Massif are Velebit (82.26%), Durmitor (77.52%) and Blidinje (74.89%) (Tab. 3). This could be expected due to the geographic position of Mt. Dinara, which lies between those three areas. Mts Učka and Biokovo are more isolated from the main Dinaric Arc, and thus have more different fauna.

Of the six compared mountain regions, Velebit and Durmitor have the highest number of recorded species (Tab. 3), probably resulting from more surveys in the past (Mihoci et al. 2007; Sijarić et al. 1984). Blidinje (Mts Čvrsnica & Vran complex) and Učka, with less than 100 recorded species, are probably still insufficiently researched. The situation with Biokovo is probably somewhat different, as it lies outside the main Dinaric chain, and is under a strong influence of the Mediterranean climate, so the 102 recorded species probably represent almost all butterflies present in the area. Although the Dinara Massif in Croatia with its 128 species is probably sufficiently researched, this number should not be considered as final. With our visits we did manage to cover the whole season of butterfly activity, but not in all the different altitudes and habitats. Our estimate is that one could probably expect at least 5–10% more species for the whole Massif, and a larger number of species for both Mt. Troglav and Mt. Kamešnica.

Interesting records

Some of the 94 recorded species require special attention. Both *Pyrgus sidae* (Esper, 1784) and *Pyrgus serratulae* (Rambur, 1839) are considered to be rare and local in Croatia, with only occasional records (Lorković 2009). They do not depend strictly on

Tab. 2. Systematic list of recorded species along with the localities, literature records, and Red List categories. ▲Cases in which genitalia dissection was used. *First record for the mountain. **CRLC – Croatian Red List Category (Šašić & Kučinić 2004). ***IUCN Red List Category for Europe (van Swaay et al. 2010), abbreviations: DD – data deficient, LC – least concern, NT – near threatened, VU – vulnerable, CR – critically endangered.

Species list▲		Locality number			Literature	CRLC**	IUCN***
		Mt. Dinara	Mt. Troglav	Mt. Kamešnica			
	HESPERIIDAE						
1.	*Hesperia comma* (Linnaeus, 1758)				Tvrtković et al. 2012		LC
2.	*Ochlodes sylvanus* (Esper, 1777)		12*		Tvrtković et al. 2012		LC
3.	*Thymelicus acteon* (Rottemburg, 1775)				Tvrtković et al. 2012	DD	NT
4.	*Thymelicus sylvestris* (Poda, 1761)		10, 12*		Tvrtković et al. 2012		LC
5.	*Thymelicus lineola* (Ochsenheimer, 1808)		10, 11, 12*		Tvrtković et al. 2012		LC
6.	*Spialia orbifer* (Hübner, 1823)			22*	Tvrtković et al. 2012		LC
7.	*Erynnis tages* (Linnaeus, 1758)	3, 6, 7, 8, 9		18, 22*	Tvrtković et al. 2012		LC
8.	*Pyrgus malvae* (Linnaeus, 1758)	8		18, 20*	Tvrtković et al. 2012		LC
9.	*Pyrgus armoricanus* (Oberthür, 1910)				Tvrtković et al. 2012		LC
10.	*Pyrgus alveus* (Hübner, 1803)	9*	12*				LC
11.	*Pyrgus serratulae* (Rambur, 1839)		12*		Tvrtković et al. 2012		LC
12.	*Pyrgus sidae* (Esper, 1784)	1, 2, 9			Tvrtković et al. 2012		LC
13.	*Carcharodus flocciferus* (Zeller, 1847)				Tvrtković et al. 2012		NT
14.	*Carcharodus alceae* (Esper, 1780)				Tvrtković et al. 2012		LC
	PAPILIONIDAE						
15.	*Iphiclides podalirius* (Linnaeus, 1758)	1, 8		18, 19, 20, 22, 23	Tvrtković et al. 2012		LC
16.	*Papilio machaon* Linnaeus, 1758	3		18, 20, 22, 23	Tvrtković et al. 2012		LC
17.	*Parnassius mnemosyne* (Linnaeus, 1758)			18*	Stauder 1920/21; Tvrtković et al. 2012	NT	NT
18.	*Parnassius apollo* (Linnaeus, 1758)		10, 11, 12	20	Mladinov 1973; Mladinov & Lorković 1985; Sijarić 1977; Tvrtković et al. 2012	VU	NT
19.	*Zerynthia polyxena* (Denis & Schiffermüller, 1775)	8			Tvrtković et al. 2012	NT	LC

Tab. 2 continued.

Species list▲		Locality number			Literature	CRLC**	IUCN***
		Mt. Dinara	Mt. Troglav	Mt. Kamešnica			
	PIERIDAE						
20.	*Aporia crataegi* (Linnaeus, 1758)		12*		Tvrtković et al. 2012		LC
21.	*Gonepteryx rhamni* (Linnaeus, 1758)	1, 2, 3, 8		18, 20	Stauder 1922; Tvrtković et al. 2012		LC
22.	*Pieris brassicae* (Linnaeus, 1758)	8			Tvrtković et al. 2012		LC
23.	*Pieris ergane* (Geyer, 1828)	1, 2, 8	12*	18,23	Mihoci et al. 2006; Tvrtković et al. 2012		LC
24.	*Pieris mannii* (Mayer, 1851)				Mihoci et al. 2006; Stauder 1913; Tvrtković et al. 2012		LC
25.	*Pieris rapae* (Linnaeus, 1758)	8		20, 23*	Tvrtković et al. 2012		LC
26.	*Pieris napi* (Linnaeus, 1758)	1			Sijarić 1977; Tvrtković et al. 2012		LC
27.	*Pieris balcana* Lorković, 1968		12*		Tvrtković et al. 2012		LC
28.	*Anthocharis cardamines* (Linnaeus, 1758)	2, 8		18*	Tvrtković et al. 2012		LC
29.	*Pontia edusa* (Fabricius, 1777)			21*	Tvrtković et al. 2012		LC
30.	*Colias caucasica* (Staudinger, 1871)				Tvrtković et al. 2011; Tvrtković et al. 2012		LC
31.	*Colias croceus* (Fourcroy, 1785)		11*	22, 23	Mihoci et al. 2006; Tvrtković et al. 2012		LC
32.	*Colias alfacariensis* Ribbe, 1905	1		18, 20, 26*	Sijarić 1977; Tvrtković et al. 2012		LC
33.	*Leptidea sinapis* (Linnaeus, 1758) ▲	8	12*	21, 22*	Tvrtković et al. 2012		LC
	LYCAENIDAE						
34.	*Satyrium acaciae* (Fabricius, 1787)				Sijarić 1977		LC
35.	*Satyrium ilicis* (Esper, 1779)		12*	21	Sijarić 1977; Tvrtković et al. 2012		LC
36.	*Satyrum spini* (Dennis & Schiffermüller, 1775)		14*	21*	Mladinov 1973; Tvrtković et al. 2012		LC
37.	*Callophrys rubi* (Linnaeus, 1758)	1, 6, 7		19*	Tvrtković et al. 2012		LC
38.	*Favonius quercus* (Linnaeus, 1758)		12*		Tvrtković et al. 2012		LC
39.	*Leptotes pirithous* (Linnaeus, 1767)				Tvrtković et al. 2012		LC

40.	*Lycaena alciphron* (Rottemburg, 1775)				Tvrtković et al. 2012		LC
41.	*Lycaena candens* (Herrich-Schäffer, 1844)				Tvrtković et al. 2012		LC
42.	*Lycaena phleas* (Linnaeus, 1761)		12*	18, 20, 21*	Tvrtković et al. 2012		LC
43.	*Lycaena tityrus* (Poda, 1761)				Tvrtković et al. 2012		LC
44.	*Lycaena virgaureae* (Linnaeus, 1758)		12*		Sijarić 1977; Tvrtković et al. 2012		LC
45.	*Cupido minimus* (Fuessly, 1775)	4, 5, 9	10*	21*	Tvrtković et al. 2012		LC
46.	*Cupido osiris* (Meigen, 1829)				Tvrtković et al. 2012		LC
47.	*Celastrina argiolus* (Linnaeus, 1758)	8			Tvrtković et al. 2012		LC
48.	*Plebejus argus* (Linnaeus, 1758)		11, 12, 14*	22*	Tvrtković et al. 2012		LC
49.	*Plebejus argyrognomon* (Bergsträsser, 1779)				Tvrtković et al. 2012		LC
50.	*Aricia agestis* (Dennis & Schiffermüller, 1775)	8, 9	12*	18, 19, 22, 23	Mihoci et al. 2006; Tvrtković et al. 2012		LC
51.	*Aricia artaxerxes* (Fabricius, 1793)		10*		Mihoci et al. 2006; Tvrtković et al. 2012		LC
52.	*Aricia eumedon* (Esper, 1780)				Sijarić 1977		LC
53.	*Cyaniris semiargus* (Rottemburg, 1775)		11, 12*		Sijarić 1977; Tvrtković et al. 2012		LC
54.	*Glaucopsyche alexis* (Poda, 1761)	8			Tvrtković et al. 2012	NT	LC
55.	*Phengaris arion* (Linnaeus, 1758)				Tvrtković et al. 2012	DD	EN
56.	*Phengaris alcon rebeli* (Hirschke, 1904)		12, 14*		Tvrtković et al. 2012	CR	LC
57.	*Scolitantides orion* (Pallas, 1771)	8			Tvrtković et al. 2012	NT	LC
58.	*Pseudophilotes vicrama* (Moore, 1865)	7, 8*	11	18, 22, 23, 24*	Tvrtković et al. 2012	DD	NT
59.	*Iolana iolas* (Ochsenheimer, 1816)	1			Tvrtković et al. 2012		NT
60.	*Polyommatus eros* (Ochsenheimer, 1808)		11*	20, 21, 22, 23*	Tvrtković et al. 2012		NT
61.	*Polyommatus icarus* (Rottemburg, 1775)	1, 2, 3, 9	10, 11*	16, 17, 18, 21, 22, 23, 24	Mihoci et al. 2006; Tvrtković et al. 2012		LC
62.	*Polyommatus thersites* (Cantener, 1835)			17, 22	Mihoci & Šašić 2006; Tvrtković et al. 2012		LC
63.	*Polyommatus amandus* (Schneider, 1792)	1	11*		Tvrtković et al. 2012		LC
64.	*Polyommatus admetus* (Esper, 1783)			26*	Koren 2010; Tvrtković et al. 2012		LC

Tab. 2 continued.

Species list▲		Locality number			Literature	CRLC**	IUCN***
		Mt. Dinara	Mt. Troglav	Mt. Kamešnica			
	PIERIDAE						
65.	*Polyommatus damon* (Denis & Schiffermüller, 1775)		14, 15*	20, 21	Mihoci et al. 2006		NT
66.	*Polyommatus escheri* (Hübner, 1823)				Tvrtković et al. 2012		LC
67.	*Polyommatus dorylas* (Denis & Schiffermüller, 1775)	2, 3, 4	11*	17, 22	Mihoci et al. 2006; Tvrtković et al. 2012		NT
68.	*Polyommatus bellargus* (Rottemburg, 1775)			17, 18	Mihoci et al. 2006; Tvrtković et al. 2012		LC
69.	*Polyommatus coridon* (Poda, 1761)			17, 18, 22, 23, 24	Mihoci et al. 2006; Sijarić 1977; Tvrtković et al. 2012		LC
70.	*Polyommatus daphnis* (Denis et Schiffermüller, 1775)				Tvrtković et al. 2012		LC
71.	*Polyommatus ripartii* (Freyer, 1830)		15*	20, 22*			LC
	RIODINIDAE						
72.	*Hamearis lucina* (Linnaeus, 1758)				Tvrtković et al. 2012		LC
	NYMPHALIDAE						
73.	*Libythea celtis* (Laicharting, 1782)			22	Mihoci et al. 2006; Mladinov 1973; Tvrtković et al. 2012		LC
74.	*Limenitis reducta* Staudinger, 1901	1	12*	16, 18, 22, 23	Mihoci et al. 2006; Tvrtković et al. 2012		LC
75.	*Neptis rivularis* (Scopoli, 1763)			20*	Tvrtković et al. 2012		LC
76.	*Nymphalis antiopa* (Linnaeus, 1758)				Tvrtković et al. 2012		LC
77.	*Nymphalis polychloros* (Linnaeus, 1758)				Tvrtković et al. 2012		LC
78.	*Vanessa atalanta* (Linnaeus, 1758)	1	12*	19	Mihoci et al. 2006; Tvrtković et al. 2012		LC
79.	*Vanessa cardui* (Linnaeus, 1758)	3		20*	Tvrtković et al. 2012		LC
80.	*Aglais io* (Linnaeus, 1758)	1			Sijarić 1977; Tvrtković et al. 2012		LC
81.	*Aglais urticae* (Linnaeus, 1758)	8		16*	Sijarić 1977; Tvrtković et al. 2012		LC

82.	*Polygonia c-album* (Linnaeus, 1758)				Tvrtković et al. 2012		LC
83.	*Argynnis adippe* (Denis & Schiffermüller, 1775)		12		Sijarić 1977; Tvrtković et al. 2012		LC
84.	*Argynnis aglaja* (Linnaeus, 1758)		10, 11, 12	18, 20*	Tvrtković et al. 2012		LC
85.	*Argynnis pandora* (Denis & Schiffermüller, 1775)		12*		Mladinov 1973; Tvrtković et al. 2012		LC
86.	*Argynnis paphia* (Linnaeus, 1758)		12	20, 21	Mihoci et al. 2006; Sijarić 1977; Tvrtković et al. 2012		LC
87.	*Issoria lathonia* (Linnaeus 1758)	6	12	18, 20*	Sijarić 1977; Tvrtković et al. 2012		LC
88.	*Brenthis daphne* (Bergsträsser, 1780)				Tvrtković et al. 2012		LC
89.	*Brenthis hecate* (Dennis & Schiffermüller, 1775)				Sijarić 1977; Tvrtković et al. 2012		LC
90.	*Boloria euphrosyne* (Linnaeus, 1758)				Tvrtković et al. 2012		LC
91.	*Melitaea didyma* (Esper, 1778)		12*	20, 23*	Mladinov 1973; Tvrtković et al. 2012		LC
92.	*Melitaea phoebe* (Denis & Schiffermüller, 1775)		12*		Tvrtković et al. 2012		LC
93.	*Melitaea trivia* (Denis et Schiffermüller, 1775)				Tvrtković et al. 2012		LC
94.	*Melitaea cinxia* (Linnaeus, 1758)	8, 9		18*	Tvrtković et al. 2012		LC
95.	*Melitaea diamina* (Lang, 1789)				Tvrtković et al. 2012		LC
96.	*Melitaea athalia* (Rottemburg, 1775) ▲		11, 12*		Tvrtković et al. 2012		LC
97.	*Melitaea britomartis* Assmann, 1847 ▲		11		Koren & Jugovic 2012	DD	NT
98.	*Euphydryas aurinia* (Rottemburg, 1775)	1, 2, 8, 9		18*	Tvrtković et al. 2012	DD	LC
99.	*Melanargia galathea* (Linnaeus, 1758)		10, 11, 12, 14*	18, 20, 22, 23	Sijarić 1977; Stauder 1922; Tvrtković et al. 2012		LC
100.	*Melanargia larissa* (Geyer, 1828)				Tvrtković et al. 2012		LC
101.	*Hipparchia fagi* (Scopoli, 1763) ▲		12*	18, 22	Mladinov 1973; Tvrtković et al. 2012		NT
102.	*Hipparchia syriaca* (Staudinger, 1871) ▲			22, 23*			LC
103.	*Hipparchia semele* (Linnaeus, 1758)		11*	18, 22	Mihoci et al. 2006; Mladinov 1973; Sijarić 1977; Tvrtković et al. 2012		LC
104.	*Neohipparchia statilinus* (Hufnagel, 1766)				Tvrtković et al. 2012		NT

Tab. 2 continued.

Species list▲		Locality number			Literature	CRLC**	IUCN***
		Mt. Dinara	Mt. Troglav	Mt. Kamešnica			
	NYMPHALIDAE						
105.	*Arethusana arethusa* (Denis & Schiffermüller, 1775)			22, 23*	Tvrtković et al. 2012		LC
106.	*Brintesia circe* (Fabricius, 1775)		11, 12, 13, 14*	21, 23, 24	Mihoci et al. 2006; Tvrtković et al. 2012		LC
107.	*Chazara briseis* (Linnaeus, 1764)		15*	20, 22, 25	Mihoci et al. 2006; Mladinov 1973; Sijarić 1977; Tvrtković et al. 2012		NT
108.	*Satyrus ferula* (Fabricius, 1793)		11, 12, 13	16, 21, 26*	Tvrtković et al. 2012		LC
109.	*Erebia aethiops* (Esper, 1777)				Tvrtković et al. 2012		LC
110.	*Erebia euryale* (Esper, 1805)		12		Sijarić 1977; Tvrtković et al. 2012		LC
111.	*Erebia ligea* (Linnaeus, 1758)		12		Mladinov & Lorković 1985; Tvrtković et al. 2012		LC
112.	*Erebia melas* (Herbst, 1796)		10, 11, 12*		Lorković 2009; Mladinov 1973; Stauder 1922; Tvrtković et al. 2012		LC
113.	*Erebia oeme* (Hübner, 1804)		10, 11		Mladinov & Lorković 1985; Sijarić 1977; Tvrtković et al. 2012		LC
114.	*Erebia ottomana* Herrich-Schäffer, 1847		10, 11, 12		Lorković 2009; Mladinov & Lorković 1985; Tvrtković et al. 2012		LC
115.	*Erebia medusa* (Denis & Schiffermüller, 1775)	3, 4			Mladinov 1973; Mladinov & Lorković 1985; Tvrtković et al. 2012	DD	LC
116.	*Erebia triaria* (de Prunner, 1798)	5, 6			Lorković 2009; Mladinov & Lorković 1985; Tvrtković et al. 2012		LC
117.	*Proterebia afra* (Fabricius, 1787)	8, 9		18	Koren et al. 2010; Tvrtković et al. 2012	DD	LC
118.	*Hyponephele lycaon* (Kühn, 1774)		12*	20	Sijarić 1977; Tvrtković et al. 2012		LC
119.	*Hyponephele lupina* (Costa, 1836)				Mladinov 1973		LC
120.	*Maniola jurtina* (Linnaeus, 1758)		13, 15*	16, 17, 21, 22	Mihoci et al. 2006; Sijarić 1977; Tvrtković et al. 2012		LC
121.	*Coenonympha arcania* (Linnaeus, 1761)				Sijarić 1977; Tvrtković et al. 2012		LC

122.	*Coenonympha glycerion* (Borkhausen, 1788)		10, 11, 12	20*	Tvrtković et al. 2012		LC
123.	*Coenonympha pamphilus* (Linnaeus, 1758)	3, 4, 9		18, 22, 23	Mihoci et al. 2006; Tvrtković et al. 2012		LC
124.	*Coenonympha rhodopensis* Elwes, 1900		11		Mladinov 1973; Sijarić 1977; Tvrtković et al. 2012		LC
125.	*Pyronia tithonius* (Linnaeus, 1758)				Tvrtković et al. 2012		LC
126.	*Lasiommata maera* (Linnaeus, 1758)				Mihoci et al. 2006; Tvrtković et al. 2012		LC
127.	*Lasiommata megera* (Linnaeus, 1767)	1, 2, 8		18, 19, 20	Sijarić 1977; Tvrtković et al. 2012		LC
128.	*Pararge aegeria* (Linnaeus, 1758)	2			Tvrtković et al. 2012		LC

higher altitudes, but records are most common there. Having no recent records for either of the two species in Croatia, these records from the Dinara Mountain chain are important. In Bosnia and Herzegovina, only several records of these species exist, and they are generally local and rare (Lelo 2007b). In nearby Montenegro, these species are more widespread and present on several localities (Jakšić 1988).

Arguably the best known European mountain butterfly, *Parnassius apollo* (Linnaeus, 1758) has previously been recorded only on the Bosnian side of Troglav (Sijarić 1977). Our records prove that this species is present also on the Croatian side, as it has been recorded both on Troglav and Kamešnica. It can be found on a few mountains in the Gorski Kotar region, as well as on Mt. Velebit (Lorković 2009). As this species was not present on Mt. Biokovo (Mihoci et al. 2011), these records probably represent the southernmost records in Croatia.

The most interesting Pieridae species recorded was *Pieris balcana* (Lorković, 1970). The main distinguishable characteristic between *P. balcana* and *P. napi* is the amount of black or greenish suffusion on the lower side of hindwing. While in *P. napi* the suffusion usually extends to the end of the wing, in *P. balcana* the suffusion is limited only to the cell and the beginning of the veins (Lorković 1989). Our record represents the only recent record as *P. balcana* was last recorded more than 20 years ago (Lorković 1989). It is probably more common in the area than previous records suggest (Lorković 1989), but due to its morphology which is very similar to *P. napi*, it was probably overlooked in many areas. The closest known localities of this species are Zelengora and Trebević in Bosnia and Herzegovina (Lorković 1989). The closest record in Croatia comes from Trnovac, located about 100 kilometers to the northwest. With our new record from Mt. Troglav, the known range in Croatia is significantly increased towards the south.

Iolana iolas (Ochsenheimer, 1816) is a Mediterranean species, in Croatia distributed mostly in the coastal zones, with rare isolated populations in the continental part (Krčmar 2002). In general, this species is not rare in Croatia, but is mostly local, limited

Tab. 3. The Dinaric Mountains with the best-surveyed butterfly faunas, along with the highest altitude, the number of recorded species, and the Sørensen similarity index between Dinara Massif and the other mountain regions.

Mountain	Highest altitude	Number of species	Sørensen similarity index
Učka	1401 m	89	71.89%
Velebit	1757 m	137	82.26%
Dinara	1913 m	128	—
Biokovo	1762 m	102	73.91%
Blidinje	2228 m	91	74.89%
Durmitor	2523 m	130	77.52%

to areas with its larval food plant, *Colutea arborescens* L. (Leguminosae). We recorded a single male on the foothills of Mt. Dinara, in the area with no larval food plant, so this individual may well represent a wandering individual. Such a case was also recorded on Mt. Velebit (Lorković 2009).

During our visit to Mt. Troglav in July, special attention was given to searching for eggs of *Phengaris alcon* (Dennis & Schiffermüller, 1775) on *Gentiana cruciata* L. (Gentianaceae). Adults were not recorded probably because it was late in the season, but we managed to find several eggs at two localities on Mt. Troglav. Approximately 20 plants were examined per locality, and on four of them we detected eggs. This species is probably more common in the area, and more targeted surveys are needed.

Polyommatus thersites (Cantener, 1835) is generally considered to be a rare species in Croatia (Mihoci et al. 2006), but recent records (Koren & Ladavac 2010; Koren et al. 2011) indicate that it is probably more common and widespread in the country. The species was recorded on both Troglav and Kamešnica in fair numbers.

The only lycaenid species recorded during this survey that inhabits only the higher altitudes was *Polyommatus eros* (Ochsenheimer, 1808). All literature records for this species originate from Mt. Velebit (Grund 1916; Lorković 2009; Steiner 1938) and Mt. Dinara, where it was mentioned as "common, but restricted to the highest altitudes" without exact locality (Tvrtković et al. 2012). Our record from the border area of Mts Troglav and Kamešnica between Croatia and Bosnia and Herzegovina significantly expands the known range in Croatia. This species was common in the area of Mt. Troglav at altitudes above 1500 m. Interestingly, on Mt. Kamešnica it was recorded at 800 m a.s.l., which is probably one of the lowest records for this species in general (Tolman & Lewington 2008).

While the presence of *Polyommatus admetus* (Esper, 1785) has previously been confirmed for Mt. Dinara (Koren 2010b), Mt. Kamešnica is a new locality. This is the commonest species of "brown" lycaenids in Croatia. It is present in several areas of southern Croatia, and generally local, but occasionally numerous (Koren 2010b).

The second species belonging to this group, *Polyommatus damon* (Denis & Schiffermüeller, 1775), has been recorded only twice before in Croatia (Koren et al. 2011; Mihoci et al. 2006). The first known locality of this species was Mt. Kamešnica (Mihoci et al. 2006), where we confirmed its presence, and we added another locality on Mt. Troglav. Both populations from Mts Kamešnica and Troglav were very numerous (Fig. 3), with

Fig. 3. *Polyommatus damon* resting on grass, Mt. Troglav.

a high number of recorded specimens. For example, on Mt. Troglav, in a small surface area of 2×2 m^2, more than 20 individuals were counted resting at sunset.

Probably one of the most interesting findings was *Polyommatus ripartii* (Freyer, 1830). This species was only recently confirmed for the butterfly fauna of Croatia (Koren 2010a). During our survey we recorded it on both Mt. Kamešnica and Mt. Troglav. In contrast to *P. damon*, *P. ripartii* was very rare on Troglav, and only a single specimen was recorded. On the other hand, on Mt. Kamešnica the population was very numerous, and more than 50 individuals were observed during our visits. These two records significantly expand the known distribution of this species in Croatia towards the south. In neighbouring Bosnia and Herzegovina, this species is also considered to be rare, with only a single confirmed record (Lelo 2007a).

One of the most interesting recorded nymphalid species was *Neptis rivularis* (Scopoli, 1763). The main area of occurrence of this species in Croatia is the northern part of the country, with just a few records from the southern part. The closest record of this species originates from Mt. Dinara (Tvrtković et al. 2012). Only a single individual was observed on Mt. Kamešnica.

From the 7 recorded species of the genus *Erebia*, probably the most notable record is that of *Erebia triaria* (de Prunner, 1798). This species was recorded previously from the area of Dinara (Lorković 2009; Mladinov & Lorković 1985; Tvrtković et al. 2012) and until now remained the only known locality in Croatia. Due to the unusually early flight period (May), and similar appearance to that of *Erebia medusa* (Denis & Schiffermüller, 1775), this species is easily overlooked. We observed this species on two localities on Dinara, where it was relatively numerous.

Of the 94 recorded species, several are of conservation concern. Some of the species are listed on the Red list of butterflies of Croatia (Šašić & Kučinić 2004) as Critically endangered (CR), Vulnerable (VU), Near Threatened (NT), or Data Deficient (DD): *Phengaris alcon* (CR); *Parnassius apollo* (VU); *Parnassius mnemosyne* (Linnaeus, 1758), *Zerynthia polyxena* (Denis & Schiffermüller, 1775), *Glaucopsyche alexis* (Poda, 1761), *Scolitantides orion* (Pallas, 1771) (NT); and *Pseudophilotes vicrama* (Moore, 1865), *Erebia medusa*, *Euphydryas aurinia* (Rottemburg, 1775), *Melitaea britomartis* Assmann, 1847 and *Proterebia afra* (Fabricius, 1787) (DD).

Ten recorded species are listed as Near Threatened in the European Red Butterfly list (van Swaay et al. 2010): *Parnassius apollo*, *Parnassius mnemosyne*, *Iolana iolas*,

Polyommatus damon, *Polyommatus dorylas* (Denis & Schiffermüller, 1775), *Polyommatus eros*, *Pseudophilotes vicrama*, *Chazara briseis* (Linnaeus, 1764), *Hipparchia fagi* (Scopoli, 1763) and *Melitaea britomartis*.

Altogether, 17 species are listed in one of the mentioned red lists. This, along with previously mentioned interesting species records, shows the importance and diversity of the surveyed area. Some species recorded during previous surveys, especially by Tvrtković et al. (2012), were not confirmed during our research. The comparison of our results with the literature is somewhat difficult, as we mostly concentrated on Mts Kamešnica and Troglav, while Tvrtković et al. (2012) concentrated mostly on Mt. Dinara. However, the differences in recorded number of species are not surprising, as the Dinara Massif is a large region, with a high number of different habitats, and we managed to visit only a small part of it. Future visits to the same localities, but in different months, should yield higher number of species for each surveyed locality.

Conclusions

The Dinara Massif, which includes four main mountains (Ilica, Dinara, Troglav and Kamešnica), is certainly one of the richest areas in the Dinaric Arc in terms of butterfly diversity. With our records and the literature records, a total of 128 species is known for the area. This number will probably grow in the future, and more new records are to be expected. Special attention should be given to Ilica Mountain, for which no data on butterfly diversity are available. One of the reasons why these mountains were not recently surveyed is their inaccessibility, especially due to the minefields left after the last war. In a certain way this favours biodiversity, because it limits human impact on the area. On the other hand, these areas are left to succession, especially after the abandonment of the traditional outdoor livestock farming.

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